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(54) **TRANSFER DEVICE AND IMAGE FORMING APPARATUS INCLUDING SAME**

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G03G 15/01 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/1665*** (2013.01); ***G03G 15/0136*** (2013.01); *G03G 15/1675* (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/1665; G03G 15/1675; G03G 15/0136
See application file for complete search history.

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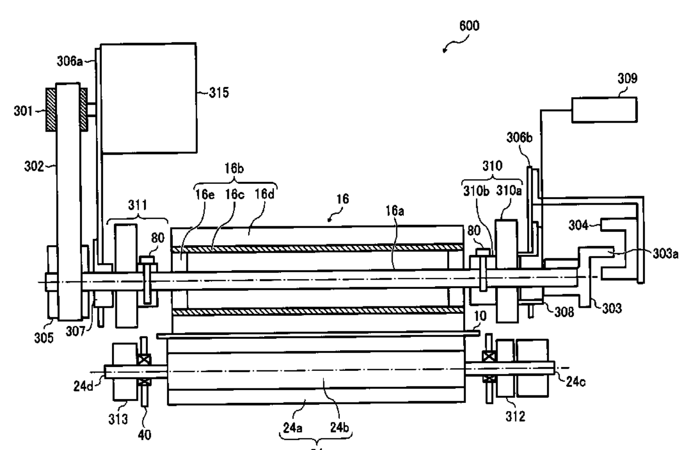
(57) **ABSTRACT**

A transfer device includes an image bearer to bear a toner image, a nip forming device to contact the image bearer to form a transfer nip, a transfer bias power source including a direct current (DC) power source and an alternating current (AC) power source electrically connected to each other to output a transfer bias including at least one of a DC bias and a superimposed bias to transfer the toner image from the image bearer onto a recording medium interposed in the transfer nip, a contact-and-separation device to cause the image bearer and the nip forming device to contact and separate from each other, and a controller to control the contact-and-separation device to increase a size of a space between the image bearer and the nip forming device upon transfer using the superimposed bias such that the space is larger than the space upon transfer using the DC bias.

9 Claims, 10 Drawing Sheets



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2014/0328604	A1	11/2014	Tanaka et al.
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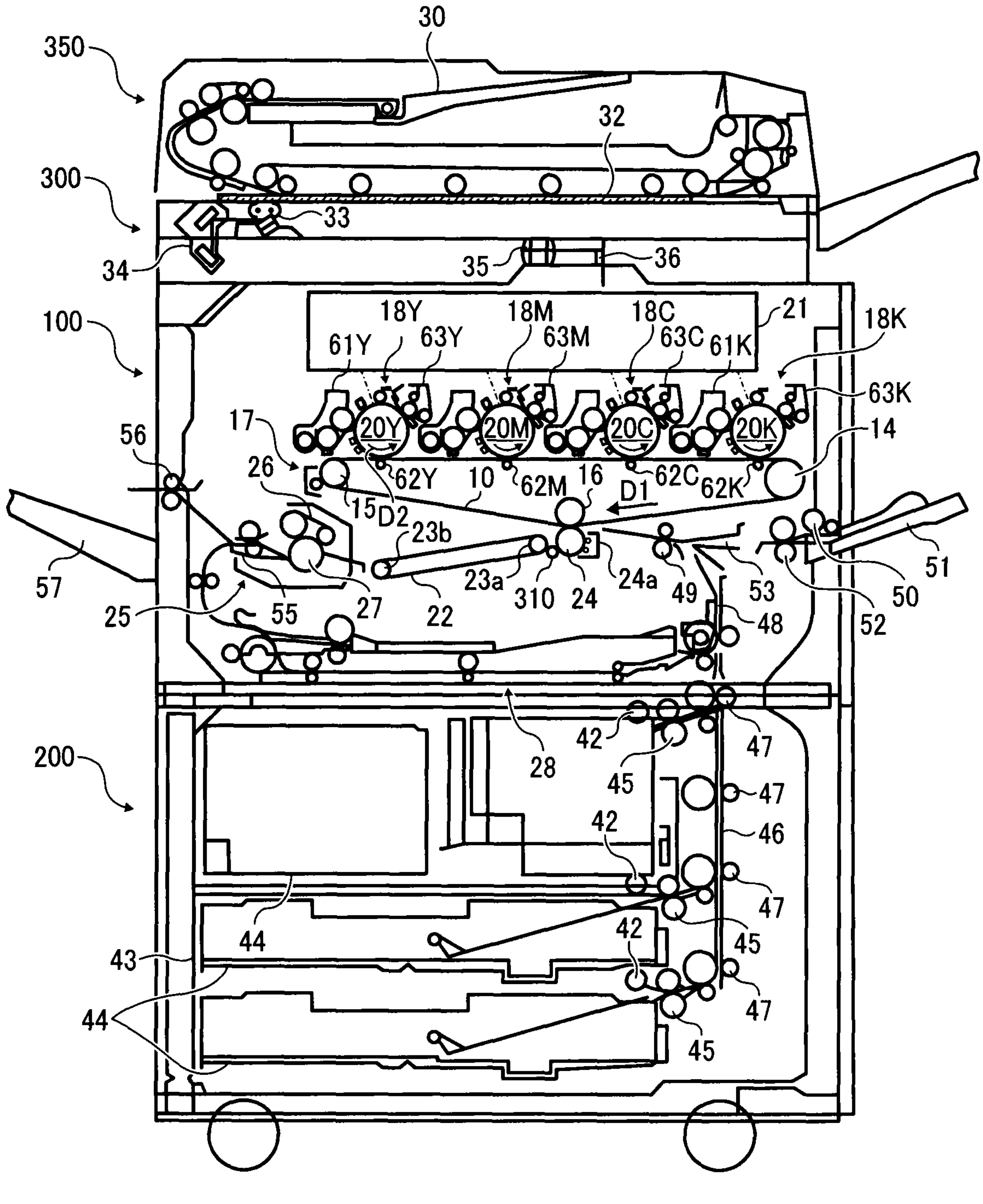
FIG. 1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30
32
300
33
34
35
36
100
18Y
18M
18C
21
18K
61Y
63Y
63M
63C
61K
63K
20Y
20M
20C
20K
17
56
26
62Y
10
62M
16
62C
62K
14
15
D2
D1
23b
57
51
23a
310
24
24a
49
53
50
25
55
27
22
48
52
28
42
47
200
45
47
46
42
47
44
45
43
42
47
44
45

FIG. 2

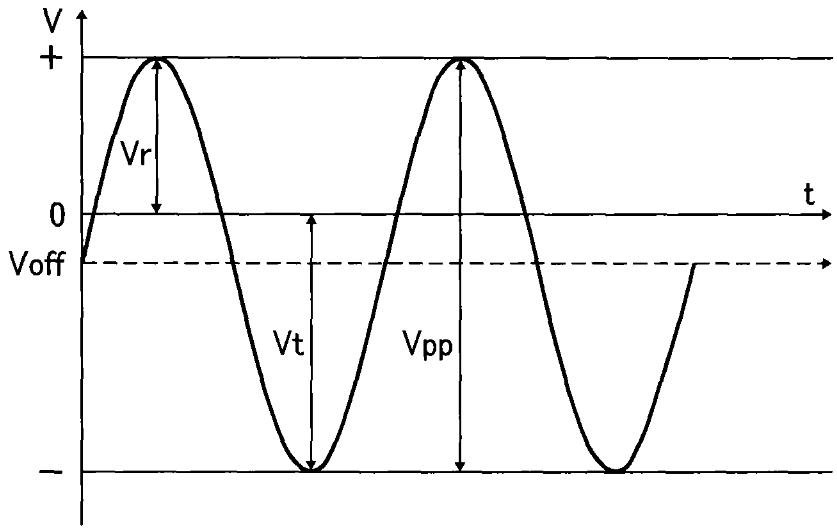


FIG. 3

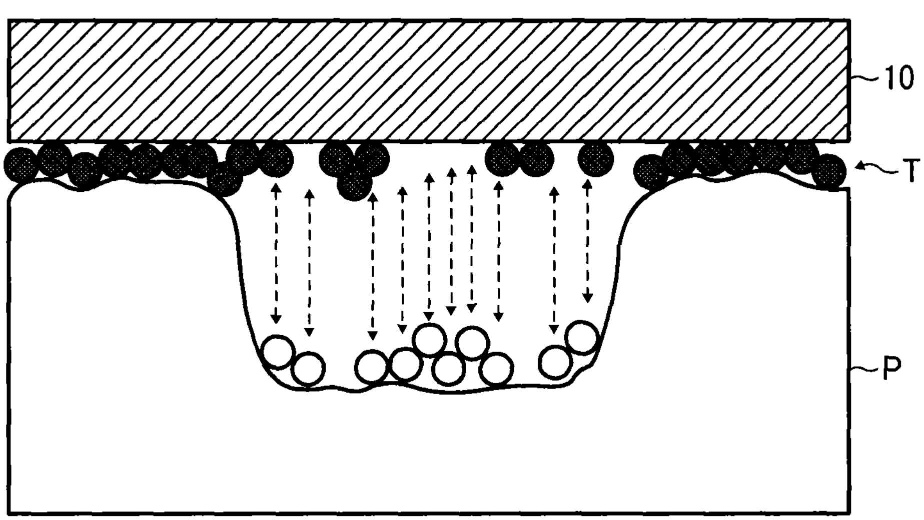


FIG. 4

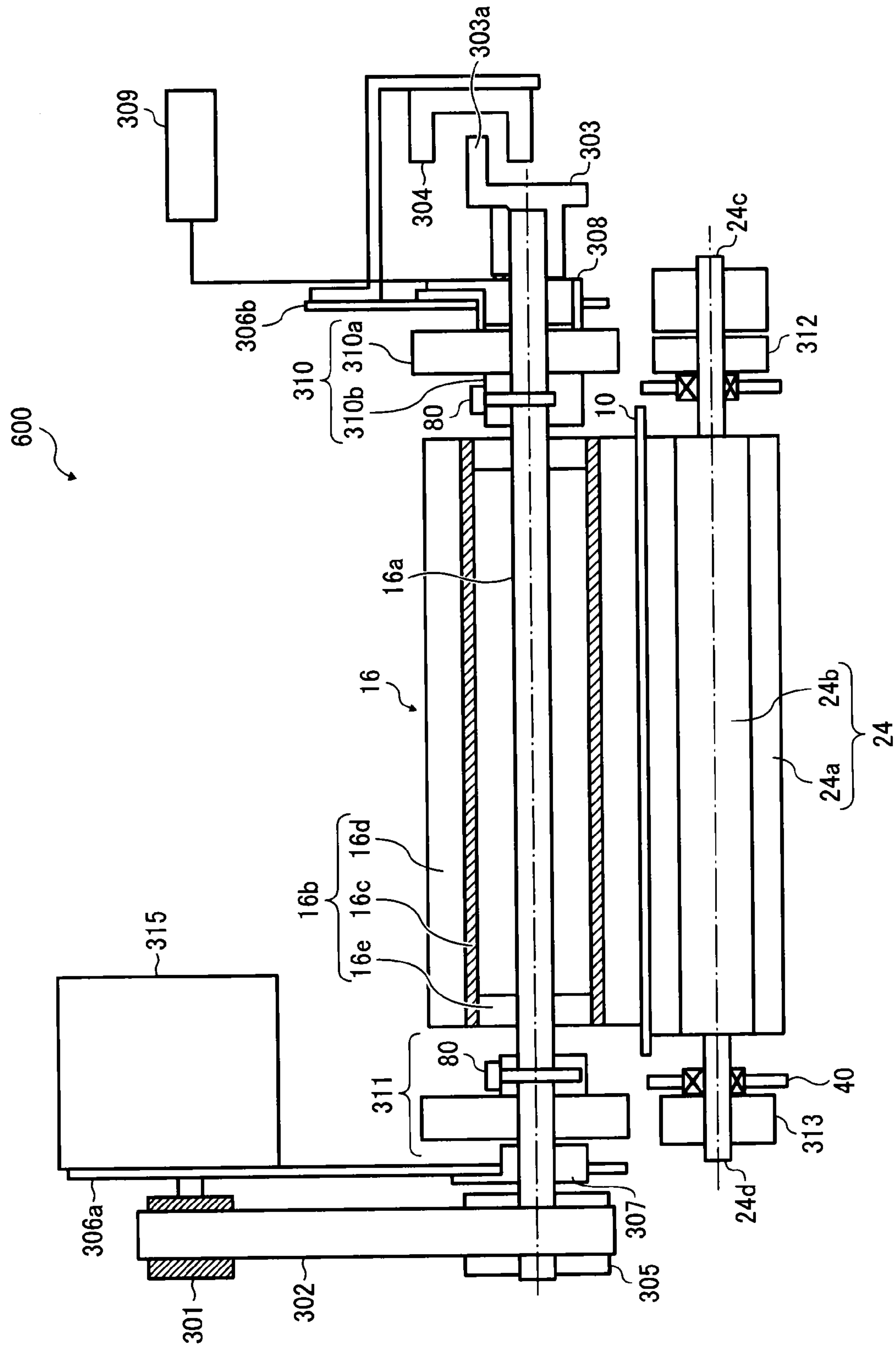

600
309
303a
303
304
308
24c
306b
310
310a
310b
312
80
10
16a
16
24b
24
24a
16b
16c
16d
16e
315
80
311
40
313
306a
307
24d
305
302
301

FIG. 5

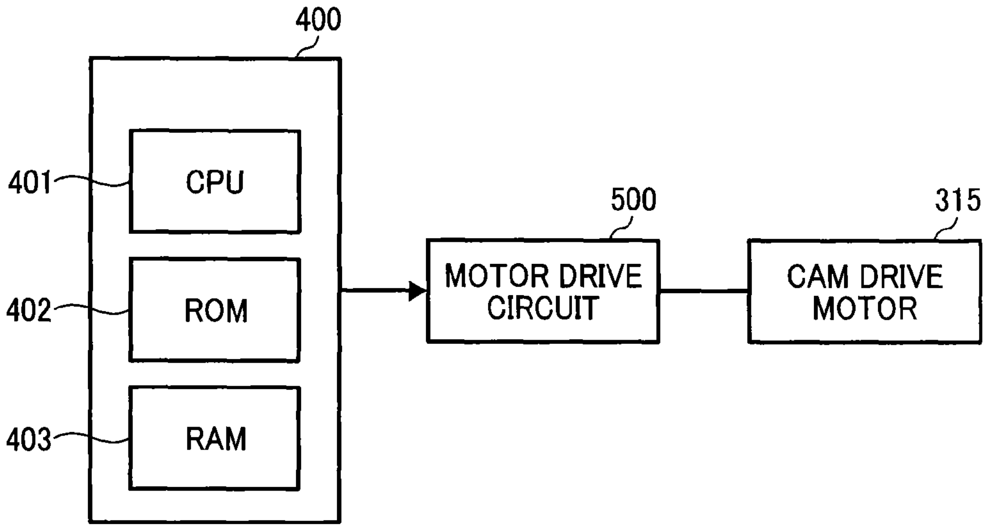

400
401
CPU
402
ROM
403
RAM
500
MOTOR DRIVE CIRCUIT
315
CAM DRIVE MOTOR

FIG. 6

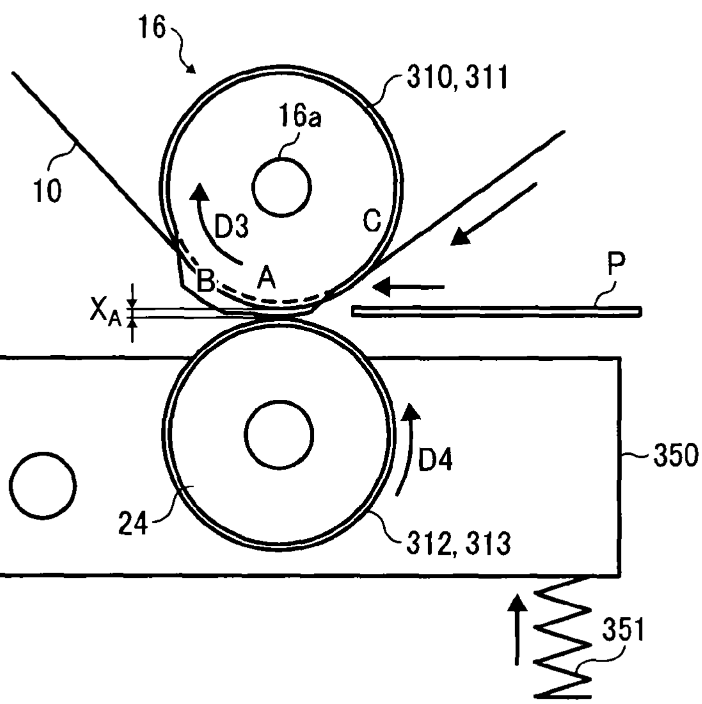

16
310, 311
16a
10
D3
C
B
A
P
X_A
D4
350
24
312, 313
351

FIG. 7

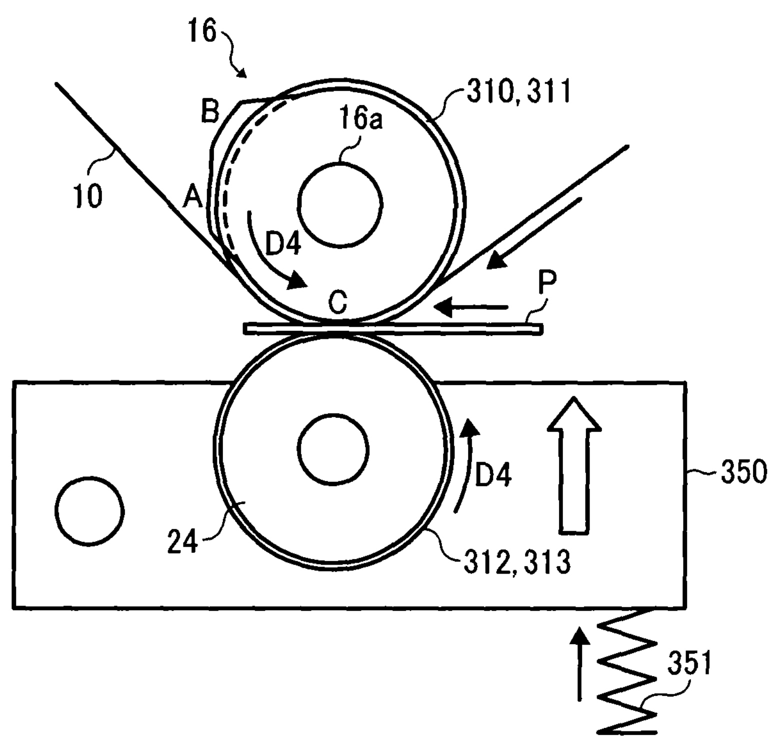


FIG. 8

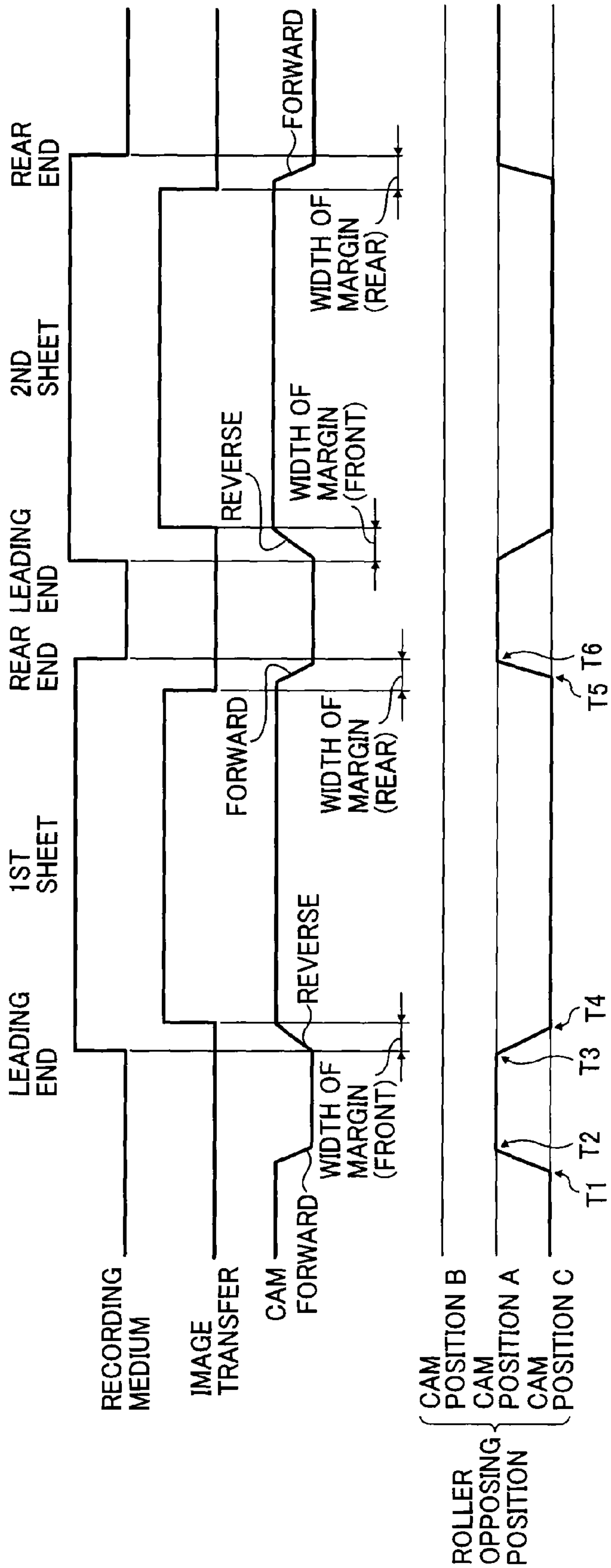

RECORDING MEDIUM
IMAGE TRANSFER
CAM FORWARD
ROLLER OPPOSING POSITION
CAM POSITION B
CAM POSITION A
CAM POSITION C
LEADING END
1ST SHEET
REAR END
LEADING END
2ND SHEET
REAR END
FORWARD
REVERSE
FORWARD
REVERSE
FORWARD
WIDTH OF MARGIN (FRONT)
WIDTH OF MARGIN (REAR)
WIDTH OF MARGIN (FRONT)
WIDTH OF MARGIN (REAR)
T1
T2
T3
T4
T5
T6

FIG. 9

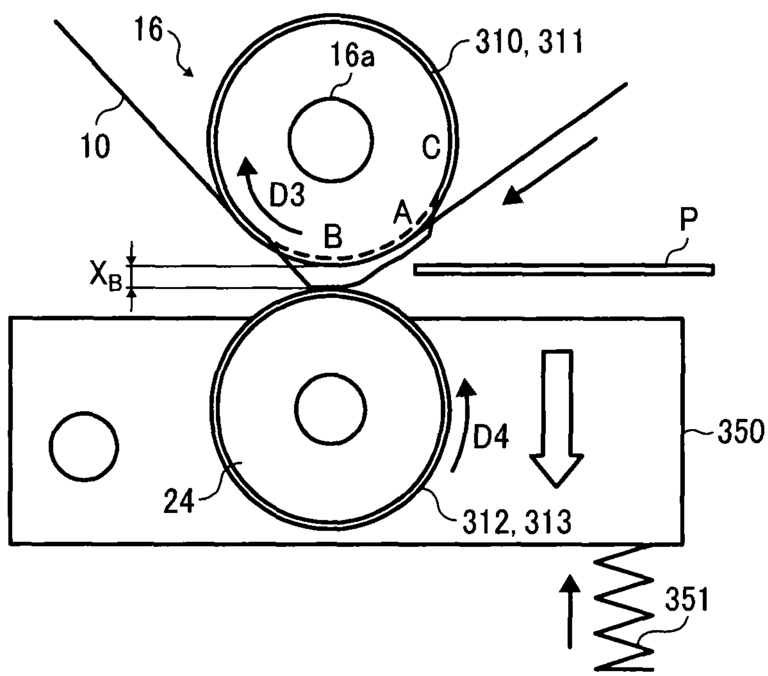


FIG. 10

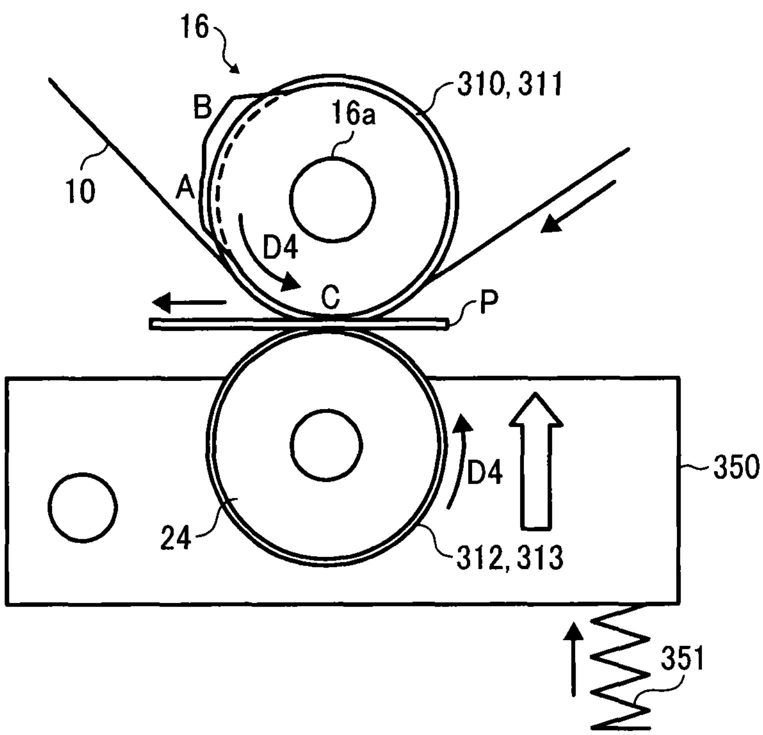


FIG. 11

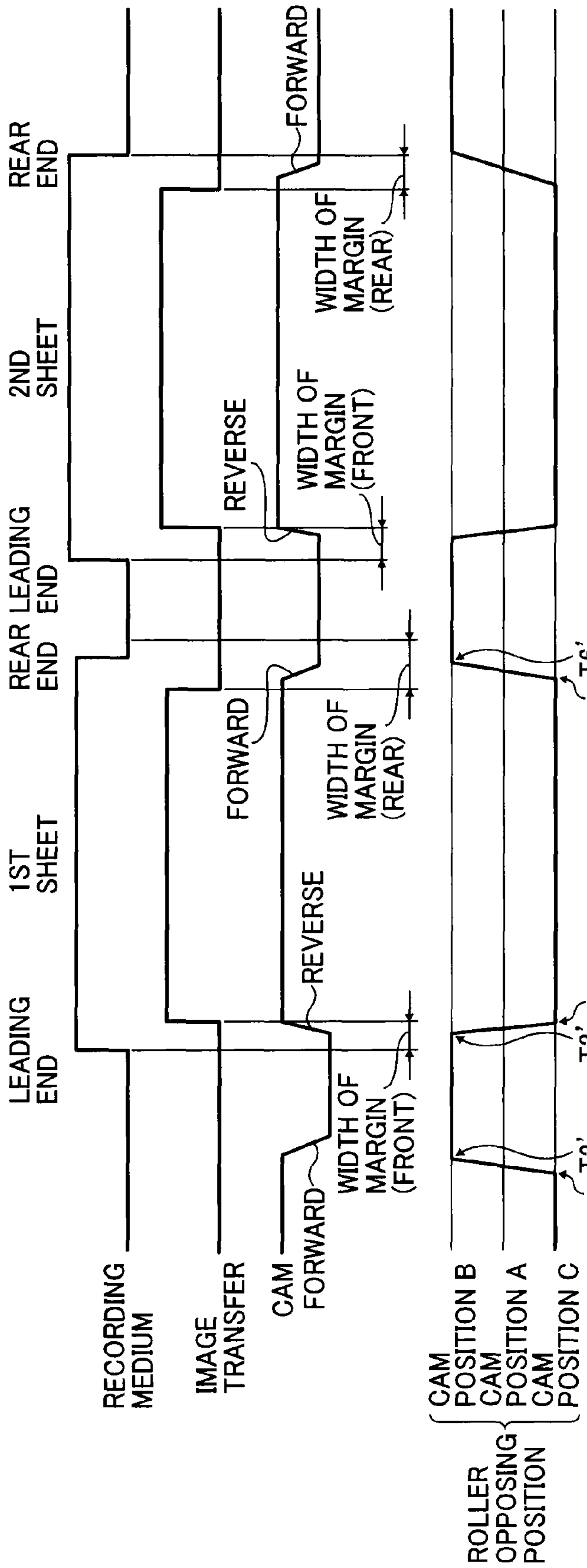
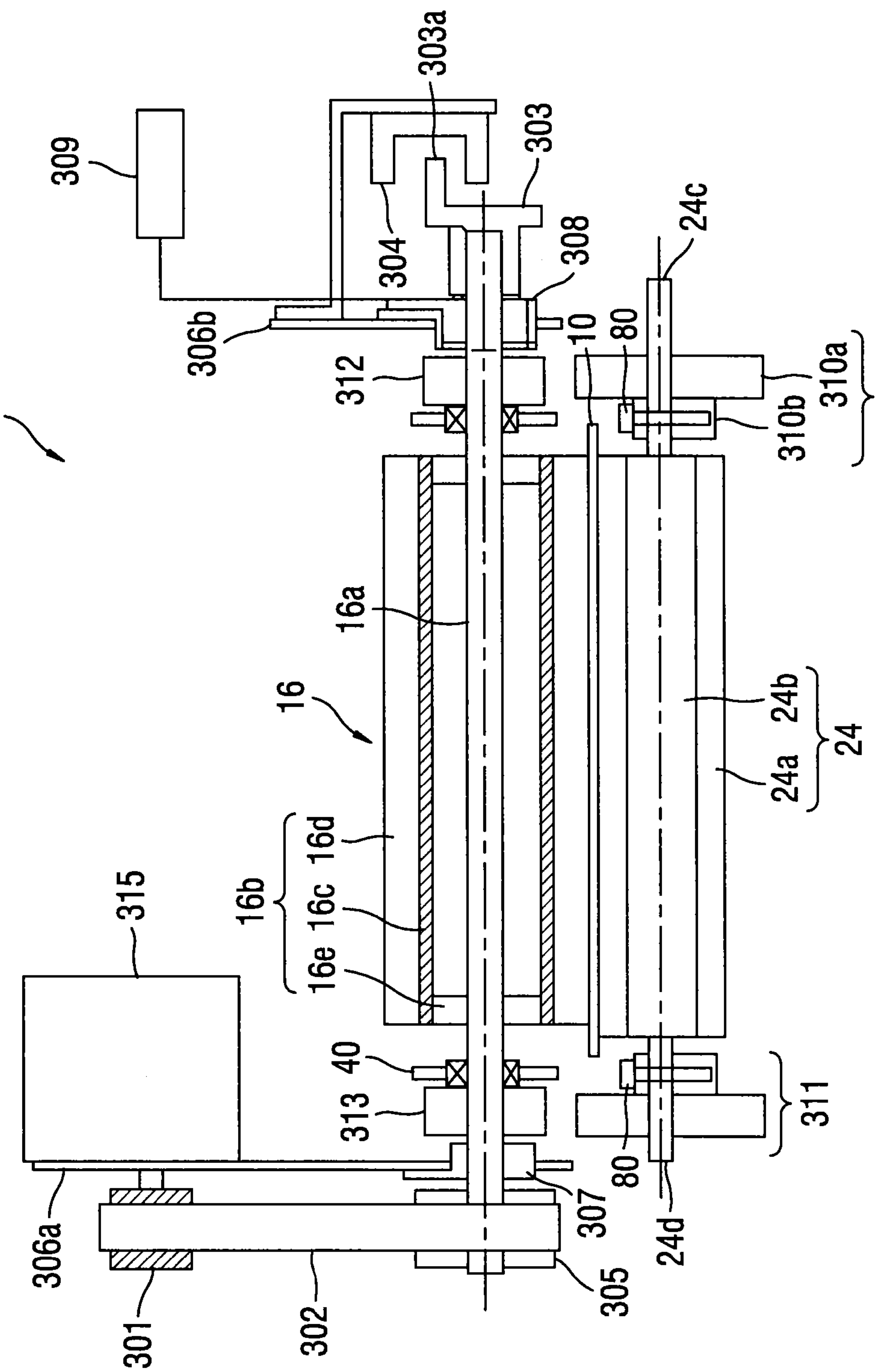

RECORDING MEDIUM
IMAGE TRANSFER
CAM FORWARD
ROLLER OPPOSING POSITION
CAM POSITION B
CAM POSITION A
CAM POSITION C
LEADING END
1ST SHEET
REAR END
REAR LEADING END
2ND SHEET
REAR END
FORWARD
REVERSE
FORWARD
REVERSE
FORWARD
WIDTH OF MARGIN (FRONT)
WIDTH OF MARGIN (REAR)
WIDTH OF MARGIN (FRONT)
WIDTH OF MARGIN (REAR)
T1' T2'
T3' T4'
T5' T6'

FIG. 12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24c
310a
310b
310
16a
16
24b
24a
24
16b
16e
16c
16d
315
40
313
80
311
306a
301
302
307
305
24d

TRANSFER DEVICE AND IMAGE FORMING APPARATUS INCLUDING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is based on and claims priority pursuant to 35 U.S.C. §119 to Japanese Patent Application No. 2014-109435, filed on May 27, 2014, in the Japan Patent Office, the entire disclosure of which is hereby incorporated by reference herein.

BACKGROUND

1. Technical Field

Exemplary aspects of the present disclosure generally relate to a transfer device and an image forming apparatus including the transfer device, and more particularly to an image forming apparatus such as a copier, a facsimile machine, a printer, or a multi-functional system including a combination thereof.

2. Description of the Related Art

There is known an image forming apparatus equipped with a transfer device that transfers a toner image from an image bearer onto a recording medium interposed in a so-called transfer nip at which the image bearer and a nip forming device contact. A transfer bias is applied to the transfer nip by a transfer bias power source to transfer the toner image from the image bearer onto the recording medium.

As an example of such a transfer device, a secondary transfer device is known to transfer secondarily a composite toner image formed on an intermediate transfer belt onto the recording medium. Toner images formed on a plurality of photoconductors are transferred onto the intermediate transfer belt in primary transfer nips between the photoconductors and the intermediate transfer belt such that they are superimposed one atop the other, thereby forming the composite toner image. The composite toner image is then transferred from the intermediate transfer belt to the recording medium by the secondary transfer device.

The secondary transfer device includes a secondary transfer roller as a nip forming device and a secondary-transfer opposed roller. The secondary transfer roller contacts the intermediate transfer belt serving as an image bearer. The secondary-transfer opposed roller is disposed opposite the secondary transfer roller via the intermediate transfer belt and contacts the intermediate transfer belt from the back thereof. The intermediate transfer belt is interposed between the secondary transfer roller and the secondary-transfer opposed roller to form the transfer nip.

One of the secondary-transfer opposed roller and the secondary transfer roller is connected to the transfer bias power source while the other roller is grounded. The transfer bias power source applies the transfer bias including a direct current (DC) voltage to the one of the secondary-transfer opposed roller and the secondary transfer roller. With this configuration, a secondary transfer electric field is formed between the secondary-transfer opposed roller and the secondary transfer roller so that the toner image moves electrostatically from the secondary-transfer opposed roller side to the secondary transfer roller side. A recording medium is fed to the secondary transfer nip in appropriate timing such that the recording medium is aligned with the toner image formed on the intermediate transfer belt. Due to the secondary transfer electric field and a nip pressure in the secondary transfer nip, the toner image on the intermediate transfer belt is secondarily transferred onto the recording medium.

In this configuration, the transfer bias applied to the secondary transfer roller or to the secondary-transfer opposed roller is subjected to constant current control. When controlling the transfer bias under constant current control, the applied voltage changes in accordance with changes in electrical resistance of the intermediate transfer belt and the secondary transfer roller caused by environmental changes such as temperature and humidity change so that transferability is stable regardless of the environmental change.

In such a configuration described above, when using a recording medium having a coarse surface or an embossed surface such as Japanese paper (also known as Washi), a pattern of light and dark (unevenness of image density) according to the surface condition of the recording medium appears in an output image. More specifically, toner does not transfer well to such embossed surfaces, in particular, recessed portions of the surface. This inadequate transfer of the toner appears as a pattern of light and dark patches in the resulting output image.

SUMMARY

In view of the foregoing, in an aspect of this disclosure, there is provided an improved transfer device including an image bearer, a nip forming device, a transfer bias power source, a contact-and-separation device, and a controller. The image bearer bears a toner image on a surface of the image bearer. The nip forming device contacts the image bearer to form a transfer nip between the nip forming device and the image bearer. The transfer bias power source includes a direct current (DC) power source and an alternating current (AC) power source electrically connected to each other, to output a transfer bias including at least one of a DC bias and a superimposed bias in which a DC voltage and an AC voltage are superimposed to transfer a toner image borne on the image bearer onto a recording medium interposed between the nip forming device and the image bearer in the transfer nip. The contact-and-separation device causes the image bearer and the nip forming device to contact and separate from each other. The controller controls the contact-and-separation device to increase a size of a space between the image bearer and the nip forming device upon transfer using the superimposed bias such that the size of the space upon transfer using the superimposed bias is larger than a size of the space upon transfer using the DC bias.

An image forming apparatus includes the transfer device to transfer the toner image formed on the image bearer onto the recording medium.

The aforementioned and other aspects, features and advantages would be more fully apparent from the following detailed description of illustrative embodiments, the accompanying drawings and the associated claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be more readily obtained as the same becomes better understood by reference to the following detailed description of illustrative embodiments when considered in connection with the accompanying drawings, wherein:

FIG. **1** is a schematic diagram illustrating a copier as an example of an image forming apparatus according to an illustrative embodiment of the present disclosure;

FIG. **2** is a waveform chart showing a waveform of a secondary bias including a superimposed bias output from a secondary transfer bias power source;

FIG. **3** is a schematic diagram illustrating an example of behavior of toner adhering to a recording medium when the secondary transfer bias power source applies the superimposed bias to a secondary-transfer opposed roller;

FIG. **4** is a schematic diagram illustrating a contact-and-separation device that causes an intermediate transfer belt and a secondary transfer roller to contact and separate from each other;

FIG. **5** is a block diagram illustrating a controller **400** employed in the image forming apparatus according to the illustrative embodiment of the present disclosure;

FIG. **6** is a schematic diagram illustrating a secondary transfer nip before the recording medium advances to the secondary transfer nip during transfer process using a direct current (DC) bias as the secondary transfer bias;

FIG. **7** is a schematic diagram illustrating the secondary transfer nip after the recording medium enters the secondary transfer nip during transfer process using the DC bias as the secondary transfer bias;

FIG. **8** is a timing diagram of rotation of cams during transfer process using the DC bias as the secondary transfer bias;

FIG. **9** is a schematic diagram illustrating the secondary transfer nip before the recording medium advances to the secondary transfer nip during transfer process using the superimposed bias as the secondary transfer bias;

FIG. **10** is a schematic diagram illustrating the secondary transfer nip after the recording medium enters the secondary transfer nip during transfer process using the superimposed bias as the secondary transfer bias; and

FIG. **11** is a timing diagram of rotation of the cams during transfer process using the superimposed bias as the secondary transfer bias; and

FIG. **12** corresponds to FIG. **4** but has the cams and idler rollers interchanged as compared to FIG. **4**.

DETAILED DESCRIPTION

A description is now given of illustrative embodiments of the present invention. It should be noted that although such terms as first, second, etc. may be used herein to describe various elements, components, regions, layers and/or sections, it should be understood that such elements, components, regions, layers and/or sections are not limited thereby because such terms are relative, that is, used only to distinguish one element, component, region, layer or section from another region, layer or section. Thus, for example, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of this disclosure.

In addition, it should be noted that the terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of this disclosure. Thus, for example, as used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. Moreover, the terms "includes" and/or "including", when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

In describing illustrative embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents that have the same function, operate in a similar manner, and achieve a similar result.

In a later-described comparative example, illustrative embodiment, and alternative example, for the sake of simplicity, the same reference numerals will be given to constituent elements such as parts and materials having the same functions, and redundant descriptions thereof omitted.

Typically, but not necessarily, paper is the medium from which is made a sheet on which an image is to be formed. It should be noted, however, that other printable media are available in sheet form, and accordingly their use here is included. Thus, solely for simplicity, although this Detailed Description section refers to paper, sheets thereof, paper feeder, etc., it should be understood that the sheets, etc., are not limited only to paper, but include other printable media as well.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, exemplary embodiments of the present patent application are described.

FIG. **1** is a schematic diagram illustrating a copier as an example of an image forming apparatus according to an illustrative embodiment of the present disclosure. The image forming apparatus includes a printer unit **100**, a paper feed unit **200**, and a scanner **300**. The printer unit **100** includes an intermediate transfer belt **10** formed into an endless loop. The intermediate transfer belt **10** is entrained about and stretched taut between a drive roller **14**, a driven roller **15**, and a secondary-transfer opposed roller **16** in such a manner that the loop of the intermediate transfer belt **10** looks like an inverted triangle shape as viewed from the side. The drive roller **14** is rotated by a driving device, and the rotation thereof enables the intermediate transfer belt **10** to travel in a clockwise direction indicated by an arrow D**1**.

The printer unit **100** includes image forming stations **18**Y, **18**M, **18**C, and **18**K, one for each of the colors yellow, magenta, cyan, and black, arranged in horizontally tandem above the looped intermediate transfer belt **10** along the traveling direction of the intermediate transfer belt **10**. It is to be noted that the suffixes Y, M, C, and K denote colors yellow, magenta, cyan, and black, respectively. To simplify the description, the reference characters Y, M, C, and K indicating colors are omitted herein unless otherwise specified.

As illustrated in FIG. **1**, the image forming stations **18**Y, **18**M, **18**C, and **18**K include photoconductors **20**Y, **20**M, **20**C, and **20**K, developing devices **61**Y, **61**M, **61**C, and **61**K, photoconductor cleaners **63**Y, **63**M, **63**C, and **63**K, respectively. The photoconductors **20**Y, **20**M, **20**C, and **20**K contact the intermediate transfer belt **10** to form primary transfer nips between each of the photoconductors **20**Y, **20**M, **20**C, and **20**K and the intermediate transfer belt **10**. The photoconductors **20**Y, **20**M, **20**C, and **20**K are driven to rotate in a counterclockwise direction indicated by an arrow D**2** by a driving device while contacting the intermediate transfer belt **10**.

Each of the developing devices **61**Y, **61**M, **61**C, and **61**K develops an electrostatic latent image formed on the photoconductors **20**Y, **20**M, **20**C, and **20**K, respectively, by supplying toners of respective colors yellow, magenta, cyan, and black. The photoconductor cleaners **63**Y, **63**M, **63**C, and **63**K remove residual toner remaining on the photoconductors **20**Y, **20**M, **20**C, and **20**K after a primary transfer process, that is, after the photoconductors **20**Y, **20**M, **20**C, and **20**K pass through the primary transfer nips.

According to the present illustrative embodiment, the four image forming stations **18**Y, **18**M, **18**C, and **18**K arranged in tandem in the traveling direction of the intermediate transfer belt **10** constitute a tandem image forming unit.

The printer unit **100** includes an optical writing unit **21** substantially above the tandem image forming unit. The optical writing unit **21** scans optically the surface of the photoconductors **20**Y, **20**M, **20**C, and **20**K rotating in the counterclockwise direction to form electrostatic latent images on the surfaces of the photoconductors **20**Y, **20**M, **20**C, and **20**K in optical writing process. Prior to the optical writing process, the surfaces of the photoconductors **20**Y, **20**M, **20**C, and **20**K are uniformly charged by charging devices.

A transfer unit includes the intermediate transfer belt **10** and primary transfer rollers **62**Y, **62**M, **62**C, and **62**K disposed inside the loop of the intermediate transfer belt **10**. The intermediate transfer belt **10** is interposed between the primary transfer rollers **62**Y, **62**M, **62**C, and **62**K, and the photoconductors **20**Y, **20**M, **20**C, and **20**K. The primary transfer rollers **62**Y, **62**M, **62**C, and **62**K pressingly contact the back of the intermediate transfer belt **10** against the photoconductors **20**Y, **20**M, **20**C, and **20**K.

A secondary transfer roller **24** is disposed below the intermediate transfer belt **10** or outside the loop of the intermediate transfer belt **10**. The secondary transfer roller **24** contacts a portion of the front surface or the image bearing surface of the intermediate transfer belt **10** wound around the secondary-transfer opposed roller **16**, thereby forming a secondary transfer nip therebetween. A sheet of recording medium P is sent to the secondary transfer nip in appropriate timing. In the secondary-transfer nip, the four-color composite toner image is transferred secondarily from the intermediate transfer belt **10** onto the recording medium P.

The scanner **300** includes a reading device **36**, i.e., a reading sensor, that reads image information of a document placed on an exposure glass. The obtained image information is sent to the controller of the printer unit **100**. Based on the image information provided by the scanner **300**, the controller controls light sources such as a laser diode and a light emitting diode (LED) of the optical writing unit **21** to illuminate the photoconductors **20**Y, **20**M, **20**C, and **20**K with light for each color. Accordingly, an electrostatic latent image is formed on the surface of each of photoconductors **20**Y, **20**M, **20**C, and **20**K. Subsequently, the electrostatic latent image is developed with toner of a respective color through developing process into toner images, one for each of the colors yellow (Y), magenta (M), cyan (C), and black (K).

The paper feed unit **200** includes multiple paper cassettes **44**, feed rollers **42**, separation rollers **45**, a sheet passage **46**, conveyor rollers **47**, and so forth. One of the feed rollers **42** is selectively rotated so as to feed a recording medium P from one of paper cassettes **44** disposed in a paper bank **43**. The separation roller **45** separates a sheet from the stack of recording media P and feeds it to the sheet passage **46**. The conveyor rollers **47** delivers the recording medium P to a sheet passage **48** of the printer unit **100**.

In addition to the paper feed unit **200**, the recording medium P can be supplied manually using a side tray **51** and a separation roller **52**. The separation roller **52** picks up and feeds a sheet of recording medium P loaded on the side tray **51** to a sheet passage **53** one sheet at a time. The sheet passage **53** meets the sheet passage **48** in the printer unit **100**.

Substantially at the end of the sheet passage **48**, a pair of registration rollers **49** is disposed. After the recording medium P delivered along the sheet passage **48** is interposed between the pair of registration rollers **49**, the pair of registration rollers **49** feeds the recording medium P to the secondary transfer nip in appropriate timing such that the recording medium P is aligned with the composite toner image formed on the intermediate transfer belt **10** in the secondary transfer nip.

Still referring to FIG. **1**, a description is provided of image forming operation for a color image. First, a document is placed on a document table **30** of an auto document feeder (hereinafter simply referred to as ADF) **350** or is placed on an exposure glass **32** of the scanner **300** by opening the ADF **350**. When the document is placed on the exposure glass **32**, the ADF **350** is closed to hold the document. Then, a start button is pressed by users. In a case in which the document is placed on the document table **30** of the ADF **350**, when a start button is pressed by users, the document is sent onto the exposure glass **32**.

Subsequently, the scanner **300** is activated, thereby moving a first carriage **33** and a second carriage **34** along the document surface. A light source of the first carriage **33** projects light against the document, which is then reflected on the document. The reflected light is reflected toward the second carriage **34**. Mirrors of the second carriage **34** reflect the light toward a focusing lens **35** which directs the light to the reading device **36**. The reading device **36** reads the document.

As the printer unit **100** receives the image information from the scanner **300**, a recording medium P having an appropriate size corresponding to the image information is supplied to the sheet passage **48**. The intermediate transfer belt **10** is rotated endlessly in the clockwise direction by the drive roller **14** which is rotated by a drive motor.

In the meantime, the photoconductors **20**Y, **20**M, **20**C, and **20**K of the image forming stations **18**Y, **18**M, **18**C, and **18**K are rotated, and the photoconductors **20**Y, **20**M, **20**C, and **20**K are subjected to various imaging processes such as charging, optical writing, and development. Through these processes, toner images of yellow, cyan, magenta, and black formed on the surface of photoconductors **20**Y, **20**M, **20**C, and **20**K are primarily transferred onto the surface of the intermediate transfer belt **10** in the respective primary transfer nips such that they are superimposed one atop the other, thereby forming a four-color composite toner image on the intermediate transfer belt **10**.

In the paper feed unit **200**, one of the feed rollers **42** is selectively rotated so as to feed a recording medium P from one of paper cassettes **44** disposed in the paper bank **43**. The recording medium P picked up by the feed roller **42** is fed to the sheet passage **46** one by one by the separation roller **45**. Subsequently, the recording medium P is delivered to the sheet passage **48** in the printer unit **100** by the conveyor rollers **47**.

When using the side tray **51**, a feed roller **50** of the side tray **51** is driven to rotate to pick up the recording medium P loaded on the side tray **51**. Then, the separation roller **52** separates and feeds the recording medium P to the sheet passage **53**. The recording medium P is delivered to the sheet passage **48**. Near the sheet passage **48**, the leading end of the recording medium P comes into contact with the pair of registration rollers **49**, and delivery of the recording medium P stops temporarily.

Subsequently, the pair of registration rollers **49** starts to rotate again to feed the recording medium P to the secondary transfer nip in appropriate timing such that the recording medium P is aligned with the four-color composite toner image formed on the intermediate transfer belt **10** in the secondary transfer nip. In the secondary transfer nip, due to transfer pressure and electric field the composite toner image is secondarily transferred onto the recording medium P.

The recording medium P, onto which the composite toner image is transferred at the secondary transfer nip, is carried on a conveyor belt **22** and delivered to a fixing device **25**. The fixing device **25** includes a pressing roller **27** and a fixing belt **26** contacting the pressing roller **27** to form a fixing nip therebetween. In the fixing device **25**, the composite toner image is fixed on the recording medium P as the recording medium P passes through the fixing nip between the fixing belt **26** and the pressing roller **27** where heat and pressure are applied. After the color toner image is formed on the recording medium P, the recording medium P is output by a pair of output rollers **56** onto an output tray **57** disposed at the exterior wall of the printer unit **100**.

In the case of double-sided printing, after the recording medium P is discharged from the fixing device **25**, a switching claw **55** changes the delivery path of the recording medium P to send it to a reversing unit **28**. In the reversing unit **28**, the recording medium P is turned upside down and returned to the pair of registration rollers **49**.

A belt cleaner **17** is disposed outside the looped intermediate transfer belt **10** and contacts the intermediate transfer belt **10** upstream from the primary transfer nip for yellow which is the extreme upstream end in the primary transfer process among the four colors.

In order to facilitate an understanding of the novel features of the present invention, as a comparison, a description is provided of a comparative example of a transfer device employed in an image forming apparatus.

In one example, the comparative example of the transfer device of the image forming apparatus employs a transfer bias power source including a DC power source and an AC power source connected to each other to apply a superimposed bias in which an AC voltage is superimposed on a DC voltage. Using such a superimposed bias, toner particles may travel back and forth between the recessed portions of the recording medium surface and the image bearer, thereby allowing the toner particles to contact the recessed portions of the recording medium surface and hence preventing transfer failure.

At this time, if the traveling speed of the intermediate transfer belt changes suddenly, an image to be transferred onto the intermediate transfer belt from the photoconductor in the primary transfer nip stretches or shrinks undesirably. As a result, the density of toner changes at a place where the density should be constant, thereby generating undesirable streaking or a so-called shock jitter.

Such a sudden change in the traveling speed of the intermediate transfer belt occurs when the recording medium enters the secondary transfer nip at which the intermediate transfer belt and the secondary transfer device meet and press against each other in the secondary transfer process. In order to reduce the shock jitter, before the recording medium enters the secondary transfer nip, the secondary transfer roller is separated from the intermediate transfer belt by an eccentric cam of a contact-and-separation device. Accordingly, the secondary transfer roller and the intermediate transfer belt are separated, and a certain space is formed therebetween, hence reducing shock jitter when the recording medium enters the secondary transfer nip.

Furthermore, immediately after the leading end of the recording medium enters the space, the secondary transfer roller is released by the eccentric cam and is pushed against the intermediate transfer belt by a spring. In this configuration, the secondary transfer roller contacts the intermediate transfer belt, and adequate transfer pressure is obtained at the secondary transfer nip during transfer, thereby preventing transfer failure.

Although advantageous, if the secondary transfer roller and the intermediate transfer belt are not separated enough, that is, the space therebetween is too small, the transfer bias applied to one of the secondary transfer roller and the transfer opposed roller leaks to the other roller. As a result, the rise time of the voltage takes long. Since a higher transfer bias is required of embossed paper than regular paper, the transfer bias gets inadequate at the leading end of the image upon transfer, and thus the image density at the leading end is low undesirably.

In view of the above, there is demand for a transfer device capable of preventing transfer failure upon transfer using a superimposed bias, and an image forming apparatus including the transfer device.

With reference to FIG. **2**, a description is provided of a secondary transfer bias output from a secondary transfer bias power source **309** (shown in FIG. **4**) according to an illustrative embodiment of the present disclosure. FIG. **2** is a waveform chart showing a waveform of the secondary bias consisting of a superimposed bias in which a direct current (DC) voltage is superimposed on an alternating current (AC) voltage. According to the present illustrative embodiment, the secondary transfer bias is applied to the metal cored bar of the secondary-transfer opposed roller **16**. The secondary transfer bias power source **309** serving as a voltage output device functions as a transfer bias application device that applies a transfer bias.

Furthermore, as described above, when the secondary transfer bias is applied to the metal cored bar of the secondary-transfer opposed roller **16**, a potential difference is generated between the metal cored bar of the secondary-transfer opposed roller **16** serving as a first transfer part and the metal cored bar of the secondary transfer roller **24** serving as a second transfer part. In other words, the secondary transfer bias power source **309** serves also as a potential difference generator. In general, a potential difference is treated as an absolute value. However, in this specification, the potential difference is expressed with polarity.

More specifically, a value obtained by subtracting the potential of the metal cored bar of the secondary transfer roller **24** from the potential of the metal cored bar of the secondary-transfer opposed roller **16** is treated as the potential difference. Using toner having the negative polarity as in the illustrative embodiment, when the polarity of the time-averaged value of the potential difference becomes negative, the potential of the secondary transfer roller **24** is increased beyond the potential of the secondary-transfer opposed roller **16** toward the opposite polarity of the charge on the toner (the positive side in the present illustrative embodiment). Accordingly, the toner is electrostatically moved from the secondary-transfer opposed roller side to the secondary transfer roller side.

In FIG. **2**, an offset voltage Voff is a value of a DC component of the secondary transfer bias. A peak-to-peak voltage Vpp is a peak-to-peak voltage of an AC component of the secondary transfer bias.

According to the present illustrative embodiment, the superimposed bias consists of a superimposed voltage in which the offset voltage Voff and the peak-to-peak voltage Vpp are superimposed. Thus, the time-averaged value of the superimposed bias coincides with the offset voltage Voff.

As described above, according to the present illustrative embodiment, the secondary transfer bias is applied to the metal cored bar of the secondary-transfer opposed roller **16** while the metal cored bar of the secondary transfer roller **24** is grounded (OV). Thus, the potential of the metal core of the secondary-transfer opposed roller **16** itself becomes the potential difference between the potentials of the metal core of the secondary-transfer opposed roller **16** and the secondary transfer roller **24**. The potential difference between the potentials of the metal cored bar of the secondary-transfer opposed roller **16** and the metal cored bar of the secondary transfer roller **24** consists of a direct current component (Eoff) having the same value as the offset voltage Voff and an alternating current component (Epp) having the same value as the peak-to-peak voltage (Vpp).

According to the present illustrative embodiment, as illustrated in FIG. **3**, the polarity of the offset voltage Voff is negative. According to the present illustrative embodiment, when the polarity of the offset voltage Voff of the secondary transfer bias applied to the secondary-transfer opposed roller **16** is negative, the toner having the negative polarity is repelled by the secondary-transfer opposed roller **16**, pushing the toner toward the secondary transfer roller **24**.

When the polarity of the secondary transfer bias is negative so is the polarity of the toner, the toner having the negative polarity is pushed out electrostatically from the secondary-transfer opposed roller **16** to the secondary transfer roller **24** in the secondary transfer nip. Accordingly, the toner on the intermediate transfer belt **10** is transferred onto the recording medium P.

By contrast, when the polarity of the secondary transfer bias is opposite that of the toner, that is, the polarity of the secondary transfer voltage is positive, the toner having the negative polarity is attracted electrostatically to the secondary-transfer opposed roller **16** from the secondary transfer roller **24**. Consequently, the toner transferred to the recording medium P is attracted again to the intermediate transfer belt **10**.

It is to be noted that because the time-averaged value (the same value as the offset voltage Voff in the present embodiment) of the secondary transfer bias has the negative polarity, the toner is pushed electrostatically from the secondary-transfer opposed roller side to the transfer roller side, relatively speaking. In FIG. **3**, Vr represents a return-direction peak potential having a peak at a positive side which is opposite the polarity of the toner. Vt represents a transfer-direction peak potential having a peak at a negative side.

With reference to FIG. **3**, a description is provided of principles of toner adhering to the recording medium P when the superimposed bias is applied to the secondary-transfer opposed roller **16** by the secondary transfer bias power source **309**.

In a case in which the superimposed bias is applied to the secondary-transfer opposed roller **16**, the waveform has an AC waveform in which a voltage moving from the secondary-transfer opposed roller **16** to the secondary transfer roller **24** and a voltage moving from the secondary transfer roller **24** to the secondary-transfer opposed roller **16** alternate in a predetermined cycle. As a result, toner particles T in the composite toner image formed on the intermediate transfer belt **10** start to move in a transfer direction toward the recording medium P and in an opposite direction. When the voltage reaches a certain level, the toner particles stick to recessed portions of the recording medium P.

Referring now to FIG. **4**, there is provided a schematic diagram illustrating a contact-and-separation device **600** serving as a moving device that causes the intermediate transfer belt **10** and the secondary transfer roller **24** to contact and separate from each other. The secondary transfer roller **24** includes a hollow, cylindrical metal cored bar **24***b*, an elastic layer **24***a* fixed to the circumferential surface of the cylindrical metal cored bar **24***b*, a first shaft **24***c*, a second shaft **24***d*, a first idler roller **312**, and a second idler roller **313**. The first shaft **24***c* and the second shaft **24***d* project from each end surface of the secondary transfer roller **24** in the axial direction. The elastic layer **24***a* is formed of elastic material.

The material constituting the cylindrical metal cored bar **24***b* includes, but is not limited to, stainless steel and aluminum. The elastic layer **24***a* has a hardness of 70° or less on Japanese Industrial Standards (JIS)-A hardness scale, for example.

In a configuration in which a cleaning device such as a cleaning blade contacts the secondary transfer roller **24** to clean the surface thereof, the elastic layer **24***a* which is too soft will cause various problems such as damage. Therefore, it is desirable that the elastic layer **24***a* have a hardness of 40° or more on JIS-A hardness scale, for example. In a case in which the secondary transfer roller **24** is not equipped with a cleaning device, the elastic layer **24***a* can be soft, thereby preventing imaging failure caused by stress applied to the secondary transfer nip when the recording medium P enters and exits the secondary transfer nip. In view of the above and in terms of productivity, a desired hardness of the elastic layer **24***a* is in a range from 40° to 50° on Asker C hardness scale.

The conductive rubber material for the elastic layer **24***a* of the secondary transfer roller **24** includes, but is not limited to, conductive epichlorohydrin rubber, Ethylene Propylene Diene Monomer (EPDM) and Si rubber in which carbon is dispersed, nitrile butadiene rubber (NBR) having ionic conductive properties, and urethane rubber. The elastic layer **24***a* fixed on the circumferential surface of the cylindrical metal cored bar **24***b* is made of conductive rubber with the resistance value thereof adjusted to have a resistance in a range of 6.5 to 7.5 Log Ω.

The electrical resistance of the elastic layer **24***a* is adjusted to a predetermined range to prevent concentration of transfer electric current at a place of contact at which the intermediate transfer belt **10** and the secondary transfer roller **24** directly contact without the recording medium P in the secondary transfer nip when a relatively small recording medium P in the axial direction of the roller, such as A5-size, is used. With an electrical resistance of the elastic layer **24***a* greater than the electrical resistance of the recording medium P, the concentration of the transfer electrical current is prevented.

The conductive rubber material for the elastic layer **24***a* includes foam rubber having a hardness in a range from 40° to 50° on Asker C hardness scale. With this configuration, the elastic layer **24***a* can deform flexibly in a thickness direction in the secondary transfer nip, thereby making the secondary transfer nip relatively wide in a transport direction of the recording medium P.

The elastic layer **24***a* has a barrel shape with a center thereof having a larger outer diameter than that of the end portions. With this configuration, the pressure at the center portion of the secondary transfer roller **24** is prevented from decreasing when the secondary transfer roller **24** is pressed against the intermediate transfer belt **10** by a coil spring **351** (shown in FIG. **6**) to form the secondary transfer nip and hence the secondary transfer roller **24** is bent.

The secondary transfer roller **24** is pressed against the intermediate transfer belt **10** entrained about the secondary-transfer opposed roller **16**. The secondary-transfer opposed roller entrained about the intermediate transfer belt **10** includes a cylindrical roller portion **16***b* as a main body and a shaft **16***a*. The shaft **16***a* penetrates through the center of rotation of the roller portion **16***b* in the axial direction while allowing the roller portion **16***b* to rotate idle on the shaft **16***a*.

The shaft **16***a* is made of metal and allows the roller portion **16***b* to rotate idle freely on the circumferential surface thereof. The roller portion **16***b* as a main body includes a drum-shaped cylindrical metal cored bar **16***c*, an elastic layer **16***d*, and a ball bearing **16***e*. The elastic layer **16***d* is fixed on the circumferential surface of the cylindrical metal cored bar **16***c* and made of elastic material. The ball bearing **16***e* is press fit to both ends of the cylindrical metal cored bar **16***c* in the axial direction thereof. While supporting the cylindrical metal cored bar **16***c*, the ball bearings **16***e* rotate on the shaft **16***a* together with the cylindrical metal cored bar **16***c*. The elastic layer **16***d* is formed on the outer circumferential surface of the cylindrical metal cored bar **16***c*.

More specifically, the shaft **16***a* is rotatably supported by a first shaft bearing **308** and a second ball bearing **307**. The first shaft bearing **308** is fixed to a first lateral plate **306***b* of the transfer unit that supports the intermediate transfer belt **10** in a stretched manner. The second ball bearing **307** is fixed to a second lateral plate **306***a*. It is to be noted that the shaft **16***a* does not rotate most of the time during print job. The shaft **16***a* allows the roller portion **16***b* that tries to rotate together with the intermediate transfer belt **10** traveling endlessly to rotate idle on the shaft **16***a*.

The elastic layer **16***d* is formed on the outer circumferential surface of the cylindrical metal cored bar **16***c* and is made of nitrile butadiene rubber (NBR) that makes the resistance in a range of 7.0 to 8.0 Log Ω.

The rubber material for the elastic layer **16***d* includes nitrile butadiene rubber (NBR) so that the elastic layer **16***d* has a hardness in a range from 48° to 58° on JIS-A hardness scale.

Cams are fixed to both ends of the shaft **16***a* of the secondary-transfer opposed roller **16**, outside the roller portion **16***b* in the longitudinal direction thereof. Each of the cams serves as contact parts that come into contact with the secondary transfer roller **24**.

More specifically, a first cam **310** is fixed to one end of the shaft **16***a* of the secondary-transfer opposed roller **16** in the longitudinal direction thereof. The first cam **310** is an eccentric cam for position adjustment. The first cam **310** includes a cam portion **310***a* and a true-circular roller portion **310***b*. The cam portion **310***a* and the roller portion **310***b* are arranged in the axial direction and constitute a single integrated unit. The roller portion **310***b* includes a parallel pin **80** that penetrates through the shaft **16***a*, thereby fixing the first cam **310** to the shaft **16***a*. A second cam **311** has the same configurations as that of the first cam **310**, and is fixed to the other end of the shaft **16***a* in the longitudinal direction thereof. The second cam **311** is an eccentric cam for position adjustment.

Furthermore, a power receiving pulley **305** is fixed outside the second cam **311** in the axial direction of the shaft **16***a*. A detection target disk **303** is fixed to the shaft **16***a* outside the first cam **310** in the axial direction of the shaft **16***a*. A cam drive motor **315** is fixed to the second lateral plate **306***a* of the transfer unit. A motor pulley **301** disposed on the shaft of the cam drive motor **315** is rotated so as to transmit, via a timing belt **302**, a driving force to the power receiving pulley **305** fixed to the shaft **16***a*.

With this configuration, the shaft **16***a* is rotated by driving the cam drive motor **315**. Even when the shaft **16***a* is rotated, the roller portion **16***b* can rotate idle freely on the shaft **16***a* so that the roller portion **16***b* can rotate together with the belt.

A stepping motor is employed as the cam drive motor **315**, thereby providing a greater freedom in setting the angle of rotation of the motor without a rotation angle detector such as an encoder.

When the shaft **16***a* stops rotating at a predetermined angle, the cam portions of the first cam **310** and the second cam **311** come into contact with the first idler roller **312** and the second idler roller **313**. The first idler roller **312** and the second idler roller **313** are disposed on the shaft of the secondary transfer roller **24**. Subsequently, the secondary transfer roller **24** is pushed against the pressure of the coil spring **351** of a roller unit retainer.

With this configuration, the distance between the shaft of the secondary-transfer opposed roller **16** and the shaft of the secondary transfer roller **24** is adjusted by moving the secondary transfer roller **24** away from the secondary-transfer opposed roller **16**, in other words, away from the intermediate transfer belt **10**.

According to the present illustrative embodiment, the first cam **310**, the second cam **311**, the cam drive motor **315**, the roller unit retainer, and so forth constitute a distance adjuster that adjusts the distance between the secondary-transfer opposed roller **16** and the secondary transfer roller **24**. As described above, the secondary-transfer opposed roller **16** serving as a rotatable support roller includes the cylindrical roller portion **16***b* and the shaft **16***a* that penetrates through the center of rotation of the roller portion **16***b* such that the roller portion **16***b* can rotate idle on the shaft **16***a*.

Rotation of the shaft **16***a* enables the first cam **310** and the second cam **311** fixed to both ends of the shaft **16***a* in the axial direction thereof to rotate together. Thus, the cams at both ends of the shaft **16***a*, that is, the first cam **310** and the second cam **311**, can be rotated by providing a power transmission device for transmission of power to the shaft **16***a* only at one end of the shaft **16***a* in the axial direction.

As described above, according to the present illustrative embodiment, the secondary transfer bias having the same polarity as that of the toner is applied to the metal cored bar of the secondary-transfer opposed roller **16** while the metal cored bar **24***b* of the secondary transfer roller **24** is grounded. With this configuration, the secondary transfer electric field is formed between the secondary-transfer opposed roller **16** and the secondary transfer roller **24** so that the toner moves electrostatically from the secondary-transfer opposed roller side to the secondary transfer roller side.

The first shaft bearing **308** that rotatably supports the shaft **16***a* made of metal is constituted of a conductive slide bearing. The secondary transfer bias power source **309** is connected to the conductive first shaft bearing **308** to output the secondary transfer bias.

The secondary transfer bias output from the secondary transfer bias power source **309** is directed to the secondary-transfer opposed roller **16** via the first shaft bearing **308**. The secondary transfer bias is transmitted through the shaft **16***a*, the ball bearing **16***e*, the metal cored bar **16***c* and the elastic layer **16***d*, accordingly. The shaft **16***a*, the ball bearing **16***e*, and the metal cored bar **16***c* are made of metal, and the elastic layer **16***d* is conductive.

The detection target disk **303** fixed to one end of the shaft **16***a* includes a detection target **303***a*. The detection target **303***a* rises in the axial direction at a predetermined position in the direction of rotation of the shaft **16***a*. An optical detector **304** is fixed to a detector bracket which is fixed to the first lateral plate **306***b* of the transfer unit.

While the shaft **16***a* rotates and comes to a predetermined rotation angle range, the detection target **303***a* of the detection target disk **303** enters between a light emitting element of the optical detector **304** and a light receiving element, shutting off the optical path therebetween. The light receiving element of the optical detector **304** sends a light receiving signal when receiving light from the light emitting element.

Based on the time at which the light receiving signal from the light receiving element is cut off and/or based on a driving amount of the cam drive motor from this time, the controller recognizes the rotation angle position of the cam portions of the first cam **310** and the second cam **311** fixed to the shaft **16***a*.

As described above, the first cam **310** and the second cam **311** come into contact with the first idler roller **312** and the second idler roller **313** at a predetermined rotation angle, thereby pushing the secondary transfer roller **24** away from the secondary-transfer opposed roller **16** against the pressure of the coil spring **351**. Thereafter, for the sake of convenience, this pushing movement of the secondary transfer roller **24** is referred to as a push down.

The amount of push down is determined by the rotation angle position of the first cam **310** and the second cam **311**. The greater is the amount of push down of the secondary transfer roller **24**, the greater is the distance between the secondary-transfer opposed roller **16** and the secondary transfer roller **24**.

The first idler roller **312** is disposed on the first shaft **24***c* of the secondary transfer roller **24** such that the first idler roller **312** can rotate idle. The first idler roller **312** is a ball bearing with an outer diameter slightly smaller than that of the secondary transfer roller **24** and can rotate idle on the circumferential surface of the first shaft **24***c*. The second idler roller **313** having the same configuration as that of the first idler roller **312** is disposed on the second shaft **24***d* of the secondary transfer roller **24** such that the first idler roller **312** can rotate idle.

As described above, the first cam **310** and the second cam **311** fixed to the shaft **16***a* of the secondary-transfer opposed roller **16** come into contact with the first idler roller **312** and the second idler roller **313** at a predetermined rotation angle. More specifically, the first cam **310** fixed to one end of the shaft **16***a* comes into contact with the first idler roller **312**. At the same time, the second cam **311** fixed to the other end of the shaft **16***a* comes into contact with the second idler roller **313**.

Rotation of the first idler roller **312** and the second idler roller **313** is stopped when the first idler roller **312** and the second idler roller **313** contact the first cam **310** and the second cam **311** of the secondary-transfer opposed roller **16**. However, rotation of the secondary transfer roller **24** is not hindered. Even when rotation of the first idler roller **312** and the second idler roller **313** stops, because the first idler roller **312** and the second idler roller **313** are ball bearings, the first shaft **24***c* and the second shaft **24***d* of the secondary transfer roller **24** can freely rotate independent of the idler rollers.

Rotation of the first idler roller **312** and the second idler roller **313** is stopped when the first idler roller **312** and the second idler roller **313** contact the first cam **310** and the second cam **311**. This configuration prevents sliding friction of the cams and the idler rollers, while preventing an increase in the torque of the belt drive motor and the drive motor for the secondary transfer roller **24**.

According to the present illustrative embodiment, in the contact-and-separation device **600** shown in FIG. **4**, the secondary-transfer opposed roller **16** includes the first cam **310** and the second cam **311**, and the secondary transfer roller **24** includes the first idler roller **312** and the second idler roller **313**. Alternatively, in some embodiments, the secondary transfer roller **24** includes the first cam **310** and the second cam **311**, and the secondary-transfer opposed roller **16** includes the first idler roller **312** and the second idler roller **313**, as shown in FIG. **12**.

FIG. **5** is a block diagram illustrating a controller **400** of the image forming apparatus according to an illustrative embodiment of the present disclosure.

The image forming apparatus includes the controller **400** that controls various operations including an image reading operation and an image forming operation. The controller includes a central processing unit (CPU) **401** to carry out control programs, a Read Only Memory (ROM) **402** to store the control programs, and a Random Access Memory (RAM) **403** to allow the control programs to be read and to temporarily store data.

A motor drive circuit **500** serving as a cam controller is operatively connected to the controller **400** to control the cam drive motor **315**. The controller **400** controls the cam drive motor **315** via the motor drive circuit **500** using the control programs stored in the ROM **402**. Accordingly, the controller **400** controls rotation of the first cam **310** and the second cam **311**.

In the present illustrative embodiment, the intermediate transfer belt **10** and the secondary transfer roller **24** are separated as needed in order to reduce shock jitter which occurs when the recording medium enters and exits the secondary transfer nip and to prevent contamination of the recording medium with a test image for adjustment of image density formed between successive recording media sheets.

FIG. **6** is a schematic diagram illustrating a secondary transfer nip before the recording medium P advances to a secondary transfer nip during the transfer process using a direct current (DC) bias as the secondary transfer bias. FIG. **7** is a schematic diagram illustrating the secondary transfer nip after the recording medium P enters the secondary transfer nip during the transfer process using the DC bias as the secondary transfer bias. FIG. **8** is a timing diagram of rotation of the first cam **310** and the second cam **311** during the transfer process using the DC bias as the secondary transfer bias.

With reference to FIGS. **6** through **8**, a description is provided of movement of the intermediate transfer belt **10** and the secondary transfer roller **24** during DC bias transfer process using the DC bias as the secondary transfer bias.

There are three stop positions, that is, a cam position A, a cam position B, and a cam position C, at which the first cam **310** and the second cam **311** stop.

As shown in FIG. **6**, when the first cam **310** and the second cam **311** are situated at the cam position A, the first cam **310** and the second cam **311** contact the first idler roller **312** and the second idler roller **313**, respectively, thereby separating the intermediate transfer belt **10** and the secondary transfer roller **24** from each other to form a space X_A therebetween.

As shown in FIG. **7**, when the first cam **310** and the second cam **311** are situated at the cam position C, the first cam **310** and the second cam **311** do not contact the first idler roller **312** and the second idler roller **313** so that the intermediate transfer belt **10** and the secondary transfer roller **24** contact.

According to the present illustrative embodiment, when performing transfer with a DC transfer bias, first, the first cam **310** and the second cam **311** situated at the cam position B are rotated forward in a direction of arrow D**3** (in a clockwise direction in FIG. **6**) before the first sheet enters the secondary transfer nip. This state corresponds to a time T**1** in FIG. **8**. Subsequently, when the first cam **310** and the second cam **311** arrive at the cam position A as illustrated in FIG. **7**, rotation of both the first cam **310** and the second cam **311** is stopped. This state corresponds to a time T**2** in FIG. **8**.

That is, when performing transfer with the DC bias, the first cam **310** and the second cam **311** push down the secondary transfer roller **24**, thereby forming the space X_A between the secondary transfer roller **24** and the intermediate transfer belt **10**. With this configuration, during the transfer with the DC bias, even when a relatively thick recording medium enters the secondary transfer nip, a significant load fluctuation does not occur relative to the intermediate transfer belt **10** and the secondary transfer roller **24**.

A desired size of the space X_A between the secondary transfer roller **24** and the intermediate transfer belt **10** is in a range from approximately 0.1 mm to 2 mm. However, the size of the space X_A is not limited thereto.

On the contrary, if the recording medium P is fed to the secondary transfer nip while the secondary transfer roller **24** is pushed down, a transfer pressure is not sufficient, resulting in degradation of transferability of the toner image. In particular, the transfer rate drops significantly when the surface of the recording medium P is not smooth.

In view of the above, according to the present illustrative embodiment, after the recording medium P enters the secondary transfer nip, the first cam **310** and the second cam **311** are rotated in an opposite direction indicated by arrow D**4** (in a counterclockwise direction in FIG. **7**). This state corresponds to a time T**3** in FIG. **8**. While a top margin at the leading end of the recording medium P passes through the secondary transfer nip, the first cam **310** and the second cam **311** are moved to the cam position C. Upon arrival of the first cam **310** and the second cam **311** at the cam position C, rotation thereof is stopped. This state corresponds to a time T**4** in FIG. **8**. It is to be noted that during image transfer, the first cam **310** and the second cam **311** remain situated at the cam position C.

Subsequently, after the toner image is transferred from the intermediate transfer belt **10** onto the recording medium P, the first cam **310** and the second cam **311** are rotated forward before the trailing edge of the recording medium P exits the secondary transfer nip. This state corresponds to a time T**5** in FIG. **8**. Subsequently, the first cam **310** and the second cam **311** are moved from the cam position C to the cam position A, and the rotation of the first cam **310** and the second cam **311** is stopped. This state corresponds to a time T**6** in FIG. **8**.

With this configuration, the first cam **310** and the second cam **311** are stopped at the cam position A, thereby separating the intermediate transfer belt **10** and the secondary transfer roller **24** from each other to form the space X_A in preparation for the trailing edge of the recording medium P to exit the secondary transfer nip. Accordingly, when the recording medium P exits the secondary transfer nip, a significant load fluctuation does not occur relative to the intermediate transfer belt **10** and the secondary transfer roller **24**. After that, the first cam **310** and the second cam **311** remain situated at the cam position A, and the next transfer with the DC bias is performed on the successive sheet of the recording medium P in a similar manner.

FIG. **9** is a schematic diagram illustrating the secondary transfer nip before the recording medium P advances to the secondary transfer nip during transfer process using a superimposed bias as the secondary transfer bias. FIG. **10** is a schematic diagram illustrating the secondary transfer nip after the recording medium P enters the secondary transfer nip during transfer process using the superimposed bias as the secondary transfer bias. FIG. **11** is a timing diagram of rotation of the first cam **310** and the second cam **311** during transfer process using the superimposed bias as the secondary transfer bias.

With reference to FIGS. **9** through **11**, a description is provided of movement of the intermediate transfer belt **10** and the secondary transfer roller **24** when performing superimposed bias transfer using the superimposed bias as the secondary transfer bias.

As shown in FIG. **9**, when the first cam **310** and the second cam **311** are situated at the cam position B, the first cam **310** and the second cam **311** contact the first idler roller **312** and the second idler roller **313**, respectively, thereby separating the intermediate transfer belt **10** and the secondary transfer roller **24** from each other to form a space X_B therebetween.

A desired size of the space X_B between the secondary transfer roller **24** and the intermediate transfer belt **10** is in a range from approximately 2 mm to 10 mm. However, the size of the space X_B is not limited thereto. However, if the space X_B is too small, electrical discharge occurs from the secondary-transfer opposed roller **16** to the secondary transfer roller **24**, thereby hindering a desired rising of voltage.

As shown in FIG. **10**, when the first cam **310** and the second cam **311** are situated at the cam position C, the first cam **310** and the second cam **311** do not contact the first idler roller **312** and the second idler roller **313** so that the intermediate transfer belt **10** and the secondary transfer roller **24** contact.

According to the present illustrative embodiment, when performing transfer with a superimposed transfer bias, first, the first cam **310** and the second cam **311** situated at the cam position B are rotated forward in the direction of arrow D**3** (in the clockwise direction in FIG. **9**) before the first sheet enters the secondary transfer nip. This state corresponds to a time T**1'** in FIG. **11**. Subsequently, when the first cam **310** and the second cam **311** arrive at the cam position B as illustrated in FIG. **9**, rotation of both the first cam **310** and the second cam **311** is stopped. This state corresponds to a time T**2'** in FIG. **11**.

That is, when performing transfer with the superimposed transfer bias, the first cam **310** and the second cam **311** push down the secondary transfer roller **24**, thereby forming the space X_B between the secondary transfer roller **24** and the intermediate transfer belt **10**. With this configuration, during the transfer with the superimposed bias, even when a relatively thick recording medium enters the secondary transfer nip, a significant load fluctuation does not occur relative to the intermediate transfer belt **10** and the secondary transfer roller **24**.

According to the present illustrative embodiment, the space X_B between the secondary transfer roller **24** and the intermediate transfer belt **10** upon transfer using the superimposed bias is larger than the space X_A between the secondary transfer roller **24** and the intermediate transfer belt **10** upon transfer using the DC bias. The space X_B provides a larger air layer between the secondary transfer roller **24** and the intermediate transfer belt **10** than the space X_A.

Due to the insulating effect of the air layer, the electrical discharge from the secondary-transfer opposed roller **16** to the secondary transfer roller **24** is difficult to occur, thereby accelerating the rise time of the voltage of the secondary-transfer opposed roller **16**. With this configuration, a sufficient amount of transfer bias is attained at the leading end of an image upon transfer using the superimposed bias, hence preventing transfer failure such as a low image density at the leading end of the image.

According to the present illustrative embodiment, after the recording medium P enters the secondary transfer nip, the first cam **310** and the second cam **311** are rotated in the opposite direction indicated by arrow D**4** (in the counterclockwise direction in FIG. **10**). This state corresponds to a time T**3'** in FIG. **11**. While the top margin at the leading end of the recording medium P passes through the secondary transfer nip, the first cam **310** and the second cam **311** are moved to the cam position C. Upon arrival of the first cam **310** and the second cam **311** at the cam position C, rotation of the first cam **310** and the second cam **311** is stopped. This state corresponds to a time T**4'** in FIG. **11**. It is to be noted that during image transfer the first cam **310** and the second cam **311** remain situated at the cam position C'.

Subsequently, after the toner image is transferred from the intermediate transfer belt **10** onto the recording medium P, the first cam **310** and the second cam **311** are rotated forward before the trailing edge of the recording medium P exits the secondary transfer nip. This state corresponds to a time T**5'** in FIG. **11**. Subsequently, the first cam **310** and the second cam **311** are moved from the cam position C to the cam position B, and the rotation of the first cam **310** and the second cam **311** is stopped. This state corresponds to a time T**6'** in FIG. **11**.

With this configuration, the first cam **310** and the second cam **311** are stopped at the cam position B, thereby separating the intermediate transfer belt **10** and the secondary transfer roller **24** to form the space X_B in preparation for the trailing edge of the recording medium P to exit the secondary transfer nip. Accordingly, when the recording medium P exits the secondary transfer nip, a significant load fluctuation does not occur relative to the intermediate transfer belt **10** and the secondary transfer roller **24**. After that, the first cam **310** and the second cam **311** remain situated at the cam position B, and the next transfer with the superimposed bias is performed on the successive sheet of the recording medium P in a similar manner described above.

It is to be noted that because a recording medium with a coarse surface requires a higher secondary transfer voltage than regular paper upon secondary transfer, preferably, the intermediate transfer belt **10** and the secondary transfer roller **24** are separated for a longer period of time than the regular paper.

According to the present illustrative embodiment, upon transfer using the superimposed bias, the time at which the separated intermediate transfer belt **10** and the secondary transfer roller **24** start contacting is delayed, later than that upon transfer using the DC bias. Accordingly, the time during which the intermediate transfer belt **10** and the secondary transfer roller **24** are separated is made long. For example, when comparing FIG. **8** with FIG. **11**, the time (the time T**3'** in FIG. **11**) after the recording medium P enters the secondary transfer nip upon transfer using the superimposed bias is later than the time (the time T**3** in FIG. **8**) at which the intermediate transfer belt **10** and the secondary transfer roller **24** start contacting upon transfer using the DC bias.

With this configuration, the intermediate transfer belt **10** and the secondary transfer roller **24** are separated for a relatively long time upon transfer using the superimposed bias, thereby bringing reliably the voltage to a target level even under some disturbances.

TABLE 1 shows example combinations of a type of recording media, a transfer method, and a time at which the intermediate transfer belt **10** and the secondary transfer roller **24** start contacting. However, the combinations are not limited to this.

TABLE 1

	REGULAR PAPER	EMBOSSED PAPER
TRANSFER METHOD	DC BIAS TRANSFER	SUPERIMPOSED BIAS TRANSFER
CONTACT START TIME	EARLY	LATE

An example of regular paper in TABLE 1 includes “My Paper” (a trade name, manufactured by NBS Ricoh Co., Ltd. having a maximum surface roughness of approximately 163 μm. An example of textured paper or rough-surface paper in TABLE 1 is “LEATHAC 66” (a trade name, manufactured by TOKUSHU PAPER MFG. CO., LTD.) having a ream weight of 260 kg (a weight of 1000 sheets) and a maximum surface roughness of approximately 163 μm. Another example of textured paper includes “FC Japanese paper SAZANAMI” (a trade name, manufactured by NBS Ricoh Co., Ltd.) having a maximum surface roughness of approximately 82 p.m.

The cam position B of the first cam **310** and the second cam **311** has a larger rotation angle than the cam position A. As a result, it takes longer for the first cam **310** and the second cam **311** to reach the target angle. When moving the first cam **310** and the second cam **311** between the cam position C and the cam position B, the rotation speed of the cam drive motor **315** is increased, thereby rotating the first cam **310** and the second cam **311** fast. More specifically, the rotation speed of the cam drive motor **315** is faster than when moving the first cam **310** and the second cam **311** between the cam position A and the cam position C. With this configuration, the time during which the first cam **310** and the second cam **311** move from the cam position C to the cam position B can be the same as the time during which the first cam **310** and the second cam **311** move from the cam position C to the cam position A.

According to the present illustrative embodiment, the rotation speed of the cam drive motor **315** when moving the first cam **310** and the second cam **311** from the cam position C to the cam position A is approximately 1500 PPS (pulses per second) at max, for example. By contrast, the motor rotation speed of the cam drive motor **315** when moving the first cam **310** and the second cam **311** from the cam position C to the cam position B is in a range from approximately 1500 PPS to 2000 PPS at max, for example.

Although the embodiment of the present disclosure has been described above, the present disclosure is not limited to the foregoing embodiments, but a variety of modifications can naturally be made within the scope of the present disclosure.

[Aspect A]

A transfer device includes an image bearer, e.g., the intermediate transfer belt **10**, to bear a toner image on a surface of the image bearer, a nip forming device, e.g., the secondary transfer roller **24** to contact the image bearer to form a transfer nip between the nip forming device and the image bearer, a transfer bias power source, e.g., the secondary transfer bias power source **309** including a direct current (DC) power source and an alternating current (AC) power source electrically connected to each other, to output a transfer bias including at least one of a DC bias and a superimposed bias in which a DC voltage and an AC voltage are superimposed to transfer a toner image borne on the image bearer onto a recording medium interposed in the transfer nip, a contact-and-separation device, e.g., the contact-and-separation device **600** to cause the image bearer and the nip forming device to contact and separate from each other, and a controller, e.g., the controller **400** to control the contact-and-separation device to increase a size of a space between the image bearer and the nip forming device upon transfer using the superimposed bias such that the space is larger than the space upon transfer using the DC bias.

According to Aspect A, the space between the image bearer and the nip forming device immediately before the recording medium enters the transfer nip upon transfer using the superimposed transfer bias is larger than that upon transfer using the DC transfer bias. With this configuration, a greater air layer is provided between the image bearer and the nip forming device, thereby enhancing the insulating effect of the air layer, and hence preventing electrical discharge in the transfer nip. As a result, the rise time of the voltage can be accelerated so that a sufficient amount of transfer bias is attained at the leading end of an image upon transfer using the superimposed bias, hence preventing transfer failure such as a low image density at the leading end of the image.

[Aspect B]

According to Aspect A, the time at which the image bearer and the nip forming device starts contacting upon transfer using the superimposed transfer bias is later than that upon transfer using the DC transfer bias.

As described above, the image bearer and the nip forming device are separated for a relatively long time, thereby bringing reliably the voltage to a target level even under some disturbances.

[Aspect C]

According to Aspect A or Aspect B, the transfer device includes a support roller including a rotary shaft disposed opposite to the nip forming device via the image bearer to rotatably support the image bearer to form the transfer nip. The nip forming device is a roller rotatable about a rotary shaft, and the image bearer is a belt. The contact-and-separation device includes a contact device, e.g., the first idler roller **312** and the second idler roller **313** disposed on at least one of the rotary shaft of the support roller and the rotary shaft of the nip forming device, an eccentric cam e.g., the first cam **310** and the second cam **311** disposed on the other one of the rotary shaft of the support roller and the rotary shaft of the nip forming device, a cam controller, e.g., the motor drive circuit **500** to rotate the eccentric cam to at least three different positions such as the cam position A, the cam position B, and the cam position C to change the size of the space between the image bearer and the nip forming device, and a biasing device, e.g., the coil spring **351** to bias the contact device in a direction in which the support roller and the nip forming device contact.

The cam controller rotates the eccentric cam to contact and move the contact device in a direction in which the image bearer and the nip forming device are separated from each other against a pressure from the biasing device, to form the space between the image bearer and the nip forming device. The cam controller rotates the eccentric cam to separate from the contact device while facing the contact device and move the contact device in a direction in which the image bearer and the nip forming device approach each other such that the support roller and the nip forming device contact each other via the image bearer with the pressure from the biasing device to form the transfer nip.

With this configuration, the eccentric cams for position adjustment can be controlled, thereby changing easily the size of the space between the image bearer and the nip forming device. Using a different size of the space upon transfer using the DC bias and upon transfer using the superimposed bias eliminates need for a large space (i.e., the space X_B) every time, hence preventing stress on the motor due to an increase in the torque and shock generated when the image bearer and the nip forming device contact again.

[Aspect D]

According to Aspect C, the rotation speed of the eccentric cams upon transfer using the superimposed bias is faster than that upon transfer using the DC bias. With this configuration, as described above, when the space between the image bearer and the nip forming device is relatively large, the time during which the image bearer and the nip forming device contact and separate from each other takes the same time as when the space therebetween is relatively small.

[Aspect E]

An image forming apparatus includes the transfer device according to any one of Aspects A through D to transfer the toner image formed on the image bearer onto the recording medium.

As described above, the space between the image bearer and the transfer device is optimized, thereby forming an image with good imaging quality.

According to an aspect of this disclosure, the present invention is employed in the image forming apparatus. The image forming apparatus includes, but is not limited to, an electrophotographic image forming apparatus, a copier, a printer, a facsimile machine, and a multi-functional system.

Furthermore, it is to be understood that elements and/or features of different illustrative embodiments may be combined with each other and/or substituted for each other within the scope of this disclosure and appended claims. In addition, the number of constituent elements, locations, shapes and so forth of the constituent elements are not limited to any of the structure for performing the methodology illustrated in the drawings.

Still further, any one of the above-described and other exemplary features of the present invention may be embodied in the form of an apparatus, method, or system.

For example, any of the aforementioned methods may be embodied in the form of a system or device, including, but not limited to, any of the structure for performing the methodology illustrated in the drawings.

Each of the functions of the described embodiments may be implemented by one or more processing circuits. A processing circuit includes a programmed processor, as a processor includes a circuitry. A processing circuit also includes devices such as an application specific integrated circuit (ASIC) and conventional circuit components arranged to perform the recited functions.

Example embodiments being thus described, it will be obvious that the same may be varied in many ways. Such exemplary variations are not to be regarded as a departure from the scope of the present invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

1. A transfer device, comprising:

an image bearer to bear a toner image on a surface of the image bearer;

a nip forming device to approach the image bearer to form a transfer nip between the nip forming device and the image bearer;

a transfer bias power source including a direct current (DC) power source and an alternating current (AC) power source electrically connected to each other, to output a transfer bias including at least one of a DC bias and a superimposed bias in which a DC voltage and an AC voltage are superimposed to transfer the toner image borne on the image bearer onto a recording medium interposed between the nip forming device and the image bearer in the transfer nip;

an approach-and-separation device to cause the image bearer and the nip forming device to approach and separate from each other; and

a controller to control the approach-and-separation device to increase a size of a space between the image bearer and the nip forming device at a start of a transfer using the superimposed bias such that the size of the space upon transfer, only when using the superimposed bias, is larger than a size of the space upon transfer using the DC bias.

2. The transfer device according to claim **1**, wherein a time period from when a leading edge of the recording medium enters the nip until an image transfer using the superimposed bias is longer than a time period from when a leading edge of the recording medium enters the nip until an image transfer using the DC bias.

3. The transfer device according to claim **1**, further comprising:

a support roller including a rotary shaft disposed opposite to the nip forming device via the image bearer to rotatably support the image bearer to form the transfer nip,

wherein the nip forming device is a roller rotatable about a rotary shaft, and the image bearer is a belt,

wherein the approach-and-separation device includes

a contact device disposed on one of the rotary shaft of the support roller and the rotary shaft of the nip forming device,

an eccentric cam disposed on the other of the rotary shaft of the support roller and the rotary shaft of the nip forming device,

a cam controller to rotate the eccentric cam to at least three different positions to change the size of the space between the image bearer and the nip forming device, and

a biasing device to bias the contact device in a direction in which the support roller and the nip forming member approach each other,

wherein the cam controller rotates the eccentric cam to contact and move the contact device in a direction in which the image bearer and the nip forming device are separated from each other against a pressure from the biasing device, to form the space between the image bearer and the nip forming device,

wherein the cam controller rotates the eccentric cam to separate from the contact device while facing the contact device and move the contact device in a direction in which the image bearer and the nip forming device approach each other such that the support roller and the nip forming device approach each other via the image bearer with the pressure from the biasing device to form the transfer nip.

4. The transfer device according to claim **3**, wherein a rotation speed of the eccentric cam upon transfer using the superimposed bias is faster than a rotation speed of the eccentric cam upon transfer using the DC bias.

5. An image forming apparatus, comprising:

the transfer device of claim **1** to transfer the toner image formed on the image bearer onto the recording medium.

6. A transfer device, comprising:

an image bearer to bear a toner image on a surface of the image bearer;

a nip forming device to approach the image bearer to form a transfer nip between the nip forming device and the image bearer;

a transfer bias power source including a direct current (DC) power source and an alternating current (AC) power source electrically connected to each other, to output a transfer bias including at least one of a DC bias and a superimposed bias in which a DC voltage and an AC voltage are superimposed to transfer the toner image borne on the image bearer onto a recording medium interposed between the nip forming device and the image bearer in the transfer nip;

an approach-and-separation device to cause the image bearer and the nip forming device to approach and separate from each other; and

a controller to control the approach-and-separation device to increase a size of a space between the image bearer and the nip forming device at a start of a transfer using the superimposed bias such that the size of the space upon transfer using the superimposed bias is larger than a size of the space upon transfer using the DC bias,

wherein a time period from when a leading edge of the recording medium enters the nip until an image transfer starts using the superimposed bias is longer than a time period from when a leading edge of the recording medium enters the nip until an image transfer using the DC bias.

7. The transfer device according to claim **6**, further comprising:

a support roller including a rotary shaft disposed opposite to the nip forming device via the image bearer to rotatably support the image bearer to form the transfer nip,

wherein the nip forming device is a roller rotatable about a rotary shaft, and the image bearer is a belt,

wherein the approach-and-separation device includes

a contact device disposed on one of the rotary shaft of the support roller and the rotary shaft of the nip forming device,

an eccentric cam disposed on the other of the rotary shaft of the support roller and the rotary shaft of the nip forming device,

a cam controller to rotate the eccentric cam to at least three different positions to change the size of the space between the image bearer and the nip forming device, and

a biasing device to bias the contact device in a direction in which the support roller and the nip forming member approach each other,

wherein the cam controller rotates the eccentric cam to contact and move the contact device in a direction in which the image bearer and the nip forming device are separated from each other against a pressure from the biasing device, to form the space between the image bearer and the nip forming device,

wherein the cam controller rotates the eccentric cam to separate from the contact device while facing the contact device and move the contact device in a direction in which the image bearer and the nip forming device approach each other such that the support roller and the nip forming device approach each other via the image bearer with the pressure from the biasing device to form the transfer nip.

8. The transfer device according to claim **7**, wherein a rotation speed of the eccentric cam upon transfer using the superimposed bias is faster than a rotation speed of the eccentric cam upon transfer using the DC bias.

9. An image forming apparatus, comprising:

the transfer device of claim **6** to transfer the toner image formed on the image bearer onto the recording medium.

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